RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**54-7963**
SRP Section:	**18 – Human Factors Engineering**
Application Section:	**18.1 HFE Program Management**
Date of RAI Issue:	**06/26/2015**

Question No. 18-4

Title 10 of the Code of Federal Regulations (10CFR) Section 52.47(a)(8) requires an applicant for a design certification to provide an FSAR which includes the information necessary to demonstrate compliance with any technically relevant portions of the Three Mile Island requirements set forth in 10 CFR 50.34(f), with certain exceptions. Section 10 CFR 50.34(f)(2)(ii) requires an applicant to "Establish a program, to begin during construction and follow into operation, for integrating and expanding current efforts to improve plant procedures. The scope of the program shall include.....human factors engineering..." The current NRC guidance for developing a human factors engineering (HFE) program is NUREG-0711, Rev 3, “Human Factors Engineering Program Review Model.” The applicant stated in the FSAR, Tier 2, Chapter 18 "Human Factors Engineering," that it was working in accordance with the criteria of NUREG-0711 in establishing its HFE program.

Section 10 CFR 50.34(f)(3) requires an applicant to provide sufficient information to demonstrate that the following requirement(s) has been met... "(i) Provide administrative procedures for evaluating operating, design and construction experience and for ensuring that applicable important industry experiences will be provided in a timely manner to those designing and constructing the plant."

NUREG-0711, Section 2.4.1 "General HFE Programs Goals and Scope," criterion 2 "Assumptions and Constraints," indicates that applicants should identify any design assumptions and constraints.

NUREG-0711, Section 3.4 "Review Criteria," Subsection 3.4.1 "Scope," criteria 1 "Predecessor/Related Plants and Systems," second bullet states that the operating experience review (OER) should define the relevance of each predecessor plant/design to the new design, when there is more than one predecessor.

APR1400-E-I-NR-14001-P, "Human Factors Engineering Program Plan," Appendix A, “NUREG-0711 Rev. 3 Conformance Table,” identifies the sections that are used to demonstrate

compliance with various NUREG-0711 acceptance review criteria. This table indicates that Section 4.1 “Assumptions and Constraints” contains the information necessary to demonstrate compliance to NUREG-0711 2.4.1,” General HFE Program Goals and Scope,” Criterion 2. Also, useful information was found in Section 8, “Definitions" of the document, as well as in FSAR Tier 2, Section 18.1.1.1 “Assumptions and Constraints Identification.”

However, additional information is required to determine if this criterion is met. Specifically, KHNP assumes that the CE 80+ design certification as the predecessor design; Palo Verde Generating Station and KHNP OPR plants as predecessor plants; and Shin-Kori 3&4 as the reference plant, are reasonable predecessor/reference designs/plants. The basis for these assumptions is not specified and the relationship to the APR1400 design is not clear.

Question 1:

Little information is provided comparing these predecessors and the differences between the designs and APR1400 is not clear. Please provide supplemental information regarding the relationship of the three designs listed here compared to APR1400. Identification of important differences between the listed designs and the likely influence on the design of the APR1400 is of particular importance.

Question 2:

Based on the information in the Program Plan, it appears that Shin-Kori 3&4, as the reference plant, is the closest design to APR1400. Has any human factors validation been completed on that design? Does it comply with NUREG-0711/NUREG-0700 or other equivalent standards?

Response

Response 1

1. OPR1000

   The nuclear steam supply system (NSSS) design of the OPR 1000 is based on Palo Verde Generating Stations (1,300MW), which is Combustion Engineering (CE) design. The turbine generator (T/G) is GE turbine generator, and the plant design was performed by KEPCO E&C and Sargent and Lundy. The OPR1000 has continuously been improved upon during construction of subsequent units at different sites.

   The major design characteristics of the OPR1000 are as follows:

   - Thermal Output: 2,825Mwt
   - Rated Electric Power: 1,000MWe
   - Design Life Time: 40 years
   - Seismic design basis: SSE 0.2g, OBE 0.1g
   - Refueling Interval: 12~18months

The OPR1000 main control room (MCR) is designed and arranged to reduce operator error and promote safe operation of the plant as well as provide operators comfort to reduce fatigue and stress. The main control boards are arranged in a U-shape and are located in the central operating area of the MCR. The design of the MCR, into which human factors engineering principles are incorporated, is such that it minimizes the operators' movements. This also facilitates accessibility of instruments and equipment for operation and maintenance.

2. Shin-Kori 3&4

The NSSS design of the Shin-Kori 3&4 is based on the CE System 80+ NSSS design. The T/G is GE design, and the plant design was performed by KEPCO E&C. The OPR1000 is the reference plant of Shin-Kori 3&4. The Shin-Kori 3 is expected to start commercial operation at the end of this year (2015). Major design characteristics of Shin-Kori 3&4 are as follows:

- Thermal Output: 4,000Mwt
- Rated Electric Power: 1,450MWe
- Design Life Time: 60 years
- Seismic design basis: SSE 0.3g, OBE 0.1g
- Core Damage Frequency: $1x10^{-5}$

Shin-Kori 3&4 MCRs are computer-based advanced control rooms which implement compact workstation type operator consoles, a large display panel, and a safety console. The human-system interfaces (HSIs) are fully digitalized I&C systems which have a common platform for the NSSS and BOP safety I&C systems and a distributed control system for the non-safety I&C systems.

3. APR1400

The APR1400 NSSS design is based on the Shin-Kori 3&4 design. Experience gained through construction of Shin-Kori 3&4 plants was used in the APR1400 design development process.

The APR1400 MCR is a computer-based advanced control room which implements compact workstation type operator consoles, a large display panel, and a safety console.

TS

TS

Response 2

TS

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Reports.

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Question No. 18-5

Section 10 CFR 52.47(a)(8) requires an applicant for a design certification to provide an FSAR which includes the information necessary to demonstrate compliance with any technically relevant portions of the Three Mile Island requirements set forth in 10 CFR 50.34(f), with certain exceptions. Section 10 CFR 50.34(f)(2)(ii) requires an applicant to "Establish a program, to begin during construction and follow into operation, for integrating and expanding current efforts to improve plant procedures. The scope of the program shall include.....human factors engineering..." The current NRC guidance for developing a human factors engineering (HFE) program is NUREG-0711, Rev 3, "Human Factors Engineering Program Review Model." The applicant stated in the FSAR, Tier 2, Chapter 18 "Human Factors Engineering," that it was working in accordance with the criteria of NUREG-0711 in establishing its HFE program.

Criterion 4, "Facilities," (NUREG-0711 Section 2.4.1, "General HFE Program Goals and Scope") allows the use of a graded HFE approach applied to “facilities other than the MCR and RSF, *providing justification* in the HFE program plan.”

Section 2, "Scope," of the HFE program plan and Section 18.1.1.2, "Applicable Plant Facilities," of the DCD Tier 2 document clearly indicate that a graded approach will be used for some parts of the design, however the justification for this is not clear, nor is the method by which this grading will occur.

Please provide a justification for the use of a graded HFE program along with a brief description about how the grading will be implemented. For instance, guidance like NUREG-0696, "Functional Criteria for Emergency Response Facilities" might be applied to the design of the EOF instead of the full scope described in NUREG-0711.

Response

All elements of NUREG-0711, Rev 3, “Human Factors Engineering Program Review Model” are applied to main control room (MCR) and remote shutdown room (RSR) and no graded program is applied for these two facilities.

The graded HFE program will be implemented in the following facilities:

1. Emergency Response Facility

   The information flat panel displays (IFPDs) used in the technical support center (TSC) uses the same display software and hardware as the IFPDs in the main control room (MCR). The emergency operation facility (EOF) will have reliable voice communication facilities to the TSC, the MCR, NRC, utility head office, and government agencies. The guidance provided in NUREG-0696, "Functional Criteria for Emergency Response Facilities" and NUREG-0700, “Human-System Interface Design Review Guidelines” are applied to the design of the TSC and the EOF instead of the full scope described in NUREG-0711, since NUREG-0696 and NUREG-0700 provide guidance specific to the design of emergency response facilities and human system interfaces, respectively.

   As per NUREG-0696 guidance, the TSC is designed to provide needed technical support to plant management and plant operating personnel during emergency conditions.

   The NUREG-0700 human factors engineering (HFE) guidelines are incorporated in the design of the TSC and EOF IFPD display formats, communication, data entry features, workspace, habitability, illumination, color coding, display character size, functional grouping, flashing, alarms, and trending.

2. Local Control Stations

   All elements of NUREG-0711, Rev 3 are applied to the local control stations (LCSs) that are associated with important human actions (IHAs), whereas the LCSs which are not associated with IHAs are designed and verified per the guidelines of NUREG-0700, “Human-System Interface Design Review Guidelines” instead of the full scope described in NUREG-0711. Since all probabilistically and deterministically identified IHAs for LCSs have already been analyzed, designed, verified and validated per NUREG-0711, the other LCSs which are not associated IHAs will not affect plant safety. Therefore, they are designed and verified per NUREG-0700 guidelines to determine conformance to design-specific HFE guidelines that include labeling, information display, controls, and environment.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Reports.

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Question No. 18-7

Criterion 6, "Subcontractor HFE Efforts," of NUREG-0711, Section 2.4.3 addresses the use of subcontractors in the HFE process. Clarification is needed regarding this process to determine if this criterion is met.

Section 18.1.3.6 “Subcontractor HFE Efforts” of the FSAR Tier 2 document states that “Subcontractor compliance with HFE requirements is demonstrated in the procurement specifications of the HSI system.” It is unclear how procurement documents typically used to acquire products/services can be used to demonstrate that various standards have been met during the process of manufacturing the product or performing a service.

Please clarify wording used in Section 18.1.3.6 “Subcontractor HFE Efforts” of the FSAR Tier 2 document.

Response

The HFE guidelines that cover design, fabrication, testing, and performance verification of annunciators, panel layout, visual displays, controls, displays, labeling and demarcation are imposed on subcontractors as contract requirements in the procurement specification.

Control of subcontractors is performed according to the KHNP quality assurance (QA) program. An audit of subcontractors’ QA programs is performed by QA personnel. The subcontractors establish their QA programs according to the subcontracts and implement their QA programs after approval.

All subcontractors’ quality management is controlled by the QA program. Compliance with HFE requirements is verified by the review of relevant HF design engineering documents such as panel layout drawings and outline drawings.

Impact on DCD

APR1400 DCD, Tier 2, Subsection 18.1.3.6 will be revised as indicated on the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Reports.

b. Operating experience review (OER) IP and ReSR

c. Functional requirements analysis and functional allocation (FRA/FA) IP and ReSR

d. Task analysis (TA) IP and ReSR

e. Staffing and qualifications (S&Q) IP and ReSR

f. Treatment of important human actions (TIHA) IP and ReSR

g. HSI design (HD) IP and ReSR

h. Human factors verification and validation (V&V) IP and ReSR

i. Design implementation (DI) IP and ReSR

The review and comment system maintains the preceding documents and makes them accessible to designers and reviewers.

18.1.3.6 Subcontractor HFE Efforts

HFE requirements are included in subcontracts to support the HFE design. ~~Subcontractor compliance with HFE requirements is demonstrated in the procurement specifications of the HSI system.~~

~~Procurement specifications for HFE design requirements and a style guide are provided to the subcontractor in a standard appendix. Subcontractor management is described in the Project Procedures Manual.~~

Insert "A" on following page

18.1.4 Tracking of HFE Issues

The ITS receives inputs from the OER and issues that are identified during the analysis, design development, and V&V. The HEDs are included in the ITS.

The HFE design team is responsible for issue logging, tracking, and resolution processes. For each issue entered into the database, cognizant engineers are assigned to resolve the

The HFE guidelines that cover design, fabrication, testing, and performance verification of annunciators, panel layout, visual displays, controls, displays, labeling and demarcation are imposed on subcontractors as contract requirements in the procurement specification.
All subcontractors' quality management is controlled by the quality assurance program. Compliance with HFE requirements is verified by the review of relevant HF design engineering documents such as panel layout drawings and outline drawings.

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Question No. 18-8

Criterion 3 "Documentation," of NUREG-0711 Section 2.4.4 “Tracking HFE Issues” indicates that licensees should document actions taken to address issues in the tracking system. Justifications should be included when no actions are required to resolve an issue.

Question 1:

Section 4.6.1.4 "Human Engineering Discrepancies Closeout," of APR1400-E-I-NR-14001-P indicates that “HEDs that do not require action are also documented in the ITS [issue tracking system].” Those HEDs that “do not require action” are later defined in the same section as Priority 3 HED “Not Priority 1 and 2 and acceptable as-is.” The description provided in this section does not explain how Priority 3 HEDs are justified and how this justification is documented.

Provide additional information to describe the justification and documentation of Priority 3 HEDs or provide references to other docketed licensing documents that address this issue.

Question 2:

Please clarify the relationship between the ITS and CAP [corrective actions program], if any. Is the HED process completely separate from the CAP or are there interfaces?

Response

Response 1

The HEDs which do not affect plant safety or operability are classified as Priority 3. Priority 3 HEDs, by definition, require no action. The review result for the classification of priorities, and justifications for actions not being required for those HEDs which are prioritized as Priority 3, are documented in the ITS.

Response 2

The HED process is completely separate from the Corrective Action Program (CAP). A comparison of the ITS and CAP is presented below.

No	Characteristics	ITS	CAP
1	Purpose	The ITS is used to track HEDs that are identified throughout the life cycle of the HFE design process, including design resolution and HED closure. The ITS enables the review, documentation and tracking of human factors issues among the design groups.	The CAP provides the requirements, responsibilities and overall process for implementing the project corrective action program to identify and correct conditions adverse to quality associated with the Project.
2	Responsible Organization	HFE design team	Project Quality Assurance (PQA) group
3	Process	• HED entry into the database • HED assessment and prioritization (i.e., Priority 1, 2, 3) • HED resolution and design implementation • HED resolution review and closeout • Documentation	• Initiate condition report (CR) • Screening - Assign a significance level (i.e., Level A, B, C, D) - For Level A, review condition under 10 CFR 21 and report defects and noncompliances to the NRC, if required • Develop root cause analysis (RCA) for Level A • Develop apparent cause evaluation (ACE) for Level B • Perform corrective actions (CAs) for Level C • Evaluate CAE and CA • Verify and close CR
4	Responsibility	• HFE design team: HED entry, review, and closeout of ITS issues • Cognizant engineer: HED assessment, prioritization, resolution, and design implementation	• Any employee: Initiate CR • Responsible engineering group: Develop RCA and ACE, perform CAs • PQA group: Coordinate screening process, evaluate CAE and CA, and verify and close CR

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

Technical Report APR1400-E-I-NR-14001-P/NP, Rev. 0, “Human Factors Engineering Program Plan”, Subsection 4.6.1.4 and 4.6.1.5 will be revised as indicated on the attached markup.

Direct safety consequences, including potential adverse effects on personnel performance. (e.g., the margin of plant safety may be reduced below an acceptable level, and must be corrected.)

2) Priority 2 HED

Not direct safety significant consequences but potential safety consequences to plant performance/operability, non-safety personnel performance/efficiency, or other factors affecting overall plant operability; corrected unless leaving the HED in an as-is condition is justified.

3) Priority 3 HED

Not Priority 1 and 2 and acceptable as-is.

The HEDs which do not affect plant safety or operability are classified as Priority 3. Priority 3 HEDs, by definition, require no action.

4.6.1.5 Documentation

HED resolutions that require a design changes are documented in the ITS and are summarized in the respective program element of the HFE program and in design documents/change orders.

The results of the HFE design program elements are documented in the respective ReSR, which includes summaries of the identified HEDs and their status. All Priority 1 HEDs and a summary of Priority 2 HEDs are included in the ReSR of HF V&V.

4.6.1.6 Responsibility

When an HED is identified and entered into the ITS, the HEF design team leader is responsible for assigning a cognizant-engineer to assess and resolve the HED and to and implement the resolution into the design. The HFE design team leader approves the official HED entry, resolution, and closeout of ITS issues.

The review result for the classification of priorities, and justifications for actions not being required for those HEDs which are prioritized as Priority 3, are documented in the ITS.

4.7 Technical Program

4.7.1 Design Process Elements

The development of implementation plans for the HFE design process, analyses, and evaluations for the following HFE elements is described in Figure 4-3. Each HFE program element, with the exception of the HFEPP, results in a ReSR being issued once the element has been completed according to its IP.

Evaluations and analyses using a full-scope MCR simulator, part-task simulator, mock-ups, and special tools and equipment are performed in support of the HFE program elements. Predecessor plant, predecessor design, and reference plant operations are also used, as described in the IPs, to provide inputs into the determination of the adequacy of the HSI design.

For use in the APR1400 HSI design, the prior resources, predecessor plant, predecessor design and reference plant are described in Section 8.

Testing and evaluation of HSI designs are conducted and documented throughout the HSI development process.

4.7.2 Element Structure

Each IP has the same structure, which is based on the review criteria in NUREG-0711. In addition, a conformance matrix is developed to ensure that all review criteria are addressed by each IP and therefore addressed in the implementation of the IP. Appendix A of each IP contains the conformance table.

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Question No. 18-10

Section 2.4.5 of NUREG-0711, criterion 4 indicates that applicants should provide information regarding the tools that will be used in the HFE program.

APR1400-E-I-NR-14001-P, Section 4.7.1 “Design Process Elements” indicates that a full-scope MCR simulator, part-task simulator, mock-ups, and special tools and equipment will be used to support HFE design work. However, it is not clear how these tools will be used to create the final design.

Please provide additional information (at a high-level) about the process or processes that will use these tools (and others described in the implementation plan) to create the final design. For instance, an applicant might describe the use of mock-ups for testing equipment outside of the control room or the applicant might use part-task simulation during the development of the full-scale simulator. The applicant may also choose to provide a reference to this material if it is considered elsewhere in the application submission.

Response

The special tools as process management tools (i.e., review and comment system, issue tracking system) are described in section 4.4.2.3 of HFE Program Plan, APR1400-E-I-NR14001-P.

The APR1400 basic HSI prototype is used for the basic HSI tests and evaluations during the development of the full-scope simulator. This prototype is developed using a SKN 3&4 plant model. It encompasses all key aspects of the basic HSI including design of physical consoles and panel configurations and arrangements, conventional controls, soft controls, selectable and spatially dedicated and continuously visible (SDCV) graphical displays, and computer-based procedures (CBPs).

The detailed functional design specifications are developed for the APR1400 full scope dynamic simulator, which is used for the APR1400 Human Factors Verification and Validation.

The APR1400 full scope dynamic simulator is developed to meet ANSI/ANS-3.5-2009, "Nuclear Power Plant Simulators for Use in Operator Training and Examination”.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Reports.